CLAIMS

We claim:

1. A method for fabricating a composite gas separation module, comprising the steps of:
   a) depositing a first material on a porous substrate, thereby forming a coated substrate;
   b) abrading the coated substrate, thereby forming a polished substrate; and
   c) depositing a second material on the polished substrate.

2. The method of Claim 1 wherein at least one of the first material and the second material includes a gas-selective material.

3. The method of Claim 2 wherein both the first material and the second material include a gas-selective material.

4. The method of Claim 2 wherein the gas-selective material is a hydrogen-selective metal or an alloy thereof.

5. The method of Claim 4 wherein the hydrogen-selective metall is palladium or an alloy thereof.

6. The method of Claim 5 wherein the hydrogen-selective metal is palladium alloyed with at least one of the metals selected from the group consisting of copper, silver, gold, platinum, ruthenium, rhodium, yttrium, cerium and indium.

7. The method of Claim 1 wherein depositing the first material on the porous substrate or depositing the second material on the polished substrate includes depositing an alloy on the porous substrate or on the polished substrate, respectively, and wherein depositing an alloy includes applying at least two metals to the porous substrate or to the polished substrate and thermally treating the metals to form the alloy.

8. The method of Claim 1 wherein at least one of the first material and the second material includes a zeolite.

9. The method of Claim 8 further including the step of depositing a hydrogen-selective metal on the material that includes a zeolite.

10. The method of Claim 1 further including the step of surface activating the porous substrate prior to depositing the first material.

11. The method of Claim 1 further including the step of depositing palladium or gold on the porous substrate prior to depositing the first material.

12. The method of Claim 1 further including the step of forming an intermetallic diffusion barrier on the porous substrate prior to depositing the first material.

13. The method of Claim 12 wherein forming an intermetallic diffusion barrier on the porous substrate includes forming a ceramic coating on the surface of the porous substrate.

14. The method of Claim 1 wherein depositing at least one of the first material and the second material on the porous substrate or the polished

substrate, respectively, includes depositing the material by a method selected from the group consisting of electroless plating, electroplating, thermal deposition, chemical vapor deposition, spray deposition, sputter coating, e-beam evaporation, ion beam evaporation and spray pyrolysis.

15. The method of Claim 1 further including the step of surface activating the polished substrate prior to depositing the second material.

16. The method of Claim 1 further including the steps of:
a) depositing a third material over the polished substrate, thereby forming a coated polished substrate;
b) abrading the coated polished substrate, thereby forming a newly-polished substrate; and
c) depositing a fourth material on the newly-polished substrate.

17. The method of Claim 16 wherein at least one of the third material and the fourth material includes a gas-selective material.

18. The method of Claim 1 further including the step of forming a dense gas-selective membrane over the porous substrate.

19. The method of Claim 18 wherein the dense gas-selective membrane includes palladium or an alloy thereof.

20. The method of Claim 18 wherein depositing the second material includes depositing a gas-selective material on the polished substrate in an amount sufficient to form a dense gas-selective membrane.

21. The method of Claim 1 wherein the porous substrate is a porous metal substrate.

22. The method of Claim 21 wherein the porous metal substrate is an alloy containing chromium and nickel.

23. The method of Claim 22 wherein the alloy further contains molybdenum.

24. The method of Claim 21 wherein the porous metal substrate is stainless steel.

25. The method of Claim 1 wherein the porous substrate is a porous ceramic substrate.

26. A composite gas separation module fabricated by the method of Claim 1.

27. A composite gas separation module comprising a porous substrate and a dense gas-selective membrane wherein the thickness of the dense gas-selective membrane is less than about three times the diameter of the largest pore of the porous substrate.

28. The composite gas separation module of Claim 27 wherein the thickness of the dense gas-selective membrane is less than about 14 microns in thickness.

29. The composite gas separation module of Claim 28 wherein the thickness of the dense gas-selective membrane is about 3 to about 14 microns.

30. The composite gas separation module of Claim 27 wherein the dense gas-selective membrane is substantially uniform in thickness.

31. The composite gas separation module of Claim 27 wherein the dense gas-selective membrane includes palladium or an alloy thereof.

32. The composite gas separation module of Claim 27 wherein the porous substrate is a porous ceramic substrate.

33. The composite gas separation module of Claim 27 wherein the porous substrate is a porous metal substrate.

34. The composite gas separation module of Claim 33 wherein the porous metal substrate is stainless steel.

35. The composite gas separation module of Claim 33 wherein the porous metal substrate is an alloy containing chromium and nickel.

36. The composite gas separation module of Claim 35 wherein the alloy further contains molybdenum.

37. The composite gas separation module of Claim 27 wherein the porous substrate contains pores having a maximum diameter of about 1 micron.

38. The composite gas separation module of Claim 27 further including an intermetallic diffusion barrier wherein the intermetallic diffusion barrier underlies the dense gas-selective membrane and overlies the porous substrate.

39. The composite gas separation module of Claim 38 wherein the intermetallic diffusion barrier includes alternating layers of palladium and layers of a Group IB metal.

40. The composite gas separation module of Claim 38 wherein the intermetallic diffusion barrier includes a ceramic coating bonded to the porous substrate and underlying the dense gas-selective membrane.

41. The composite gas separation module of Claim 27 wherein hydrogen flux through the module is at least about 4 Nm^3/m^2-hr at about 350°C and with a hydrogen partial pressure difference of about 1 bar.

42. A method for selectively separating hydrogen gas from a hydrogen gas-containing gaseous stream, comprising the step of:

directing the hydrogen gas-containing gaseous stream to a composite gas separation module; wherein the composite gas separation module includes a porous substrate and a dense hydrogen-selective membrane, and wherein the thickness of the dense hydrogen-selective membrane is less than about three times the diameter of the largest pore of the porous substrate, whereby hydrogen gas is at least partially partitioned from the gaseous stream by passing through the dense hydrogen-selective membrane.

43. The method of Claim 42 further including the step of reacting hydrogen gas-producing reactants to produce the gaseous stream.

44. The method of Claim 42 wherein the dense hydrogen-selective membrane includes palladium or an alloy thereof.

45. The method of Claim 42 wherein the porous substrate contains pores having a maximum diameter of about 1 micron.

46. The method of Claim 42 wherein the thickness of the dense gas-selective membrane is less than about 14 microns in thickness.

47. The method of Claim 46 wherein the thickness of the dense gas-selective membrane is about 3 to about 14 microns.

48. A method for fabricating a plated substrate, comprising the steps of:

a) plating a porous substrate with a first metal, thereby forming a coated substrate;

b) abrading the coated substrate, thereby forming a polished substrate; and

c) plating the polished substrate with a second metal, thereby forming the plated substrate.

49. The method of Claim 48 wherein at least one of the first metal and the second metal includes a hydrogen-selective metal or an alloy thereof.

50. The method of Claim 49 wherein the hydrogen-selective metal is palladium or an alloy thereof.

51. The method of Claim 50 wherein the hydrogen-selective metal is palladium alloyed with at least one of the metals selected from the group consisting of copper, silver, gold, platinum, ruthenium, rhodium, yttrium, cerium and indium.

52. The method of Claim 48 wherein both the first metal and the second metal include a hydrogen-selective metal or an alloy thereof.

53. The method of Claim 49 wherein the hydrogen-selective metal is palladium or an alloy thereof.

54. The method of Claim 48 wherein plating the polished substrate with the second metal includes forming a dense hydrogen-selective metal membrane.